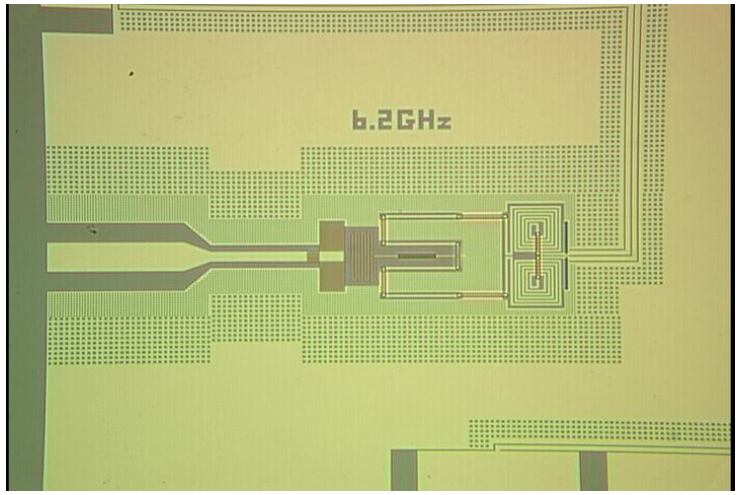
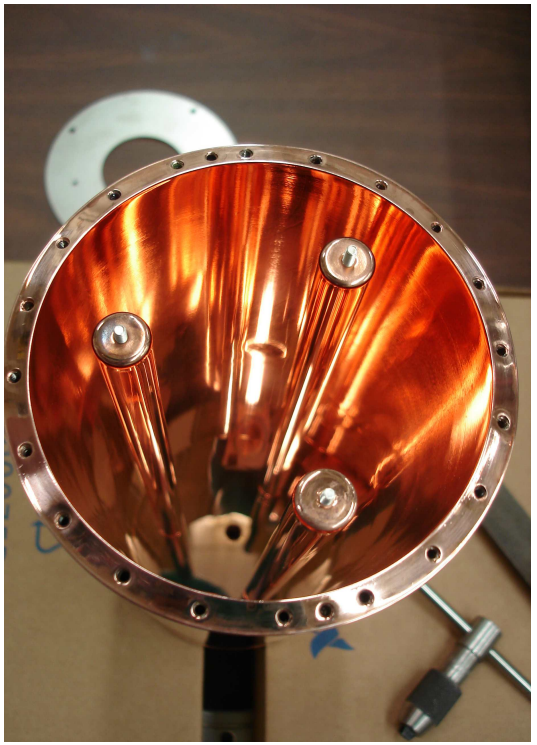


Axion Dark Matter Xperiment – High Frequency



Steve Lamoreaux, Karl van Bibber

Cosmic Frontier Workshop – 3.6.2013

ADMX-HF (Hi-Frequency) rationale & history

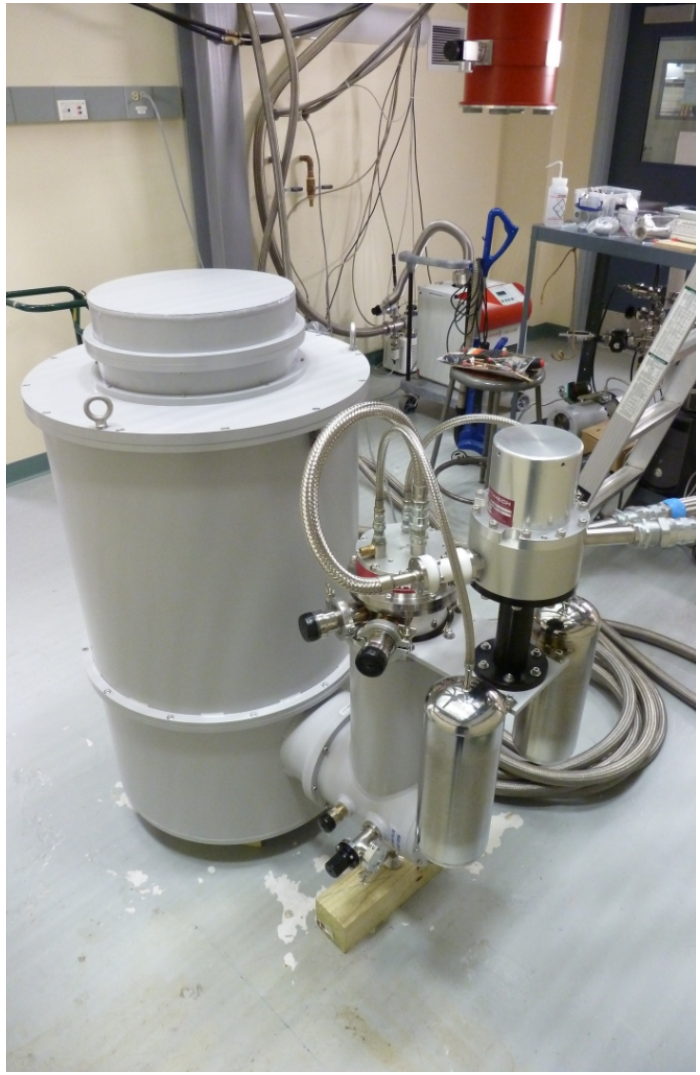
- Second platform focusing on
  - Higher masses 10-1000 μeV (~ 2.5 - 250 GHz), and
  - Sweeping out mass fast & efficiently
- ADMX-HF goal is two-fold:
  - As a data *pathfinder* with medium sensitivity (KSVZ or better)
  - As an *innovation test-bed*
- Subset of ADMX (Yale, JILA, Berkeley, LLNL)
- NSF funded 2011
  - Project going very well, and is ahead of schedule ($\Delta \approx 1$ yr)
  - Will integrate & commission winter-spring 2013

ADMX subsumes the entirety of the US dark matter axion effort, and as a consequence now has a complete strategy

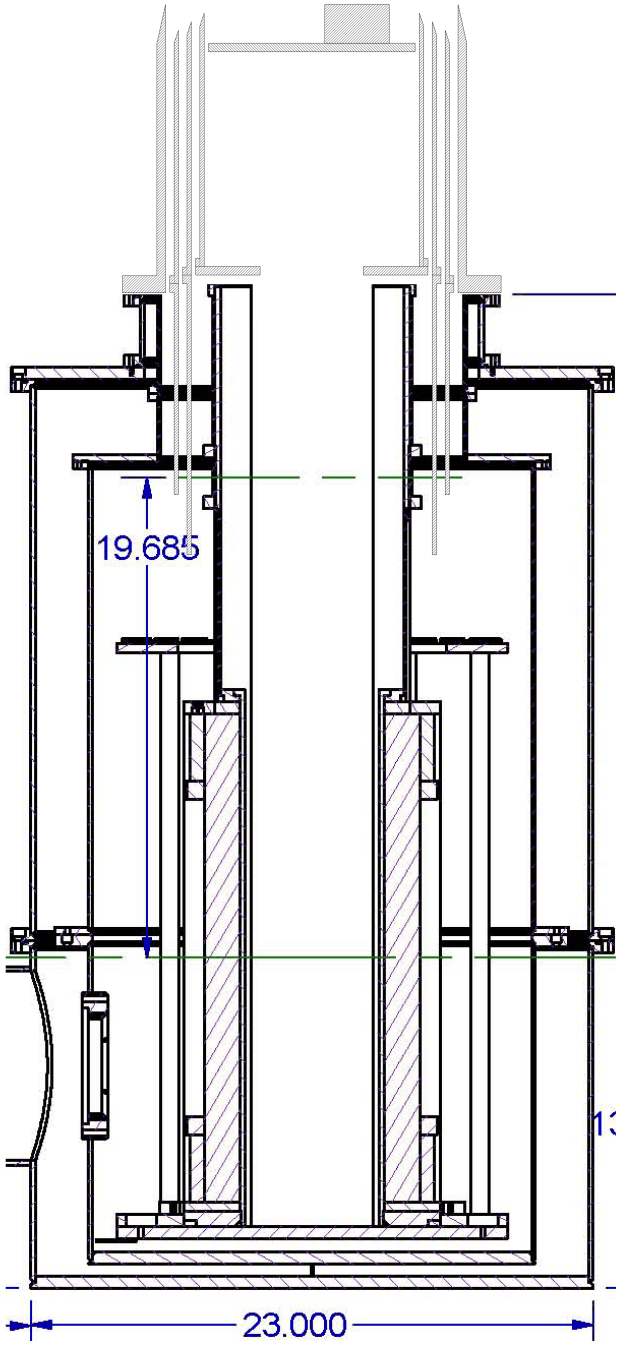
ADMX-HF at Yale is a rather small experiment !

Microwave Cavity

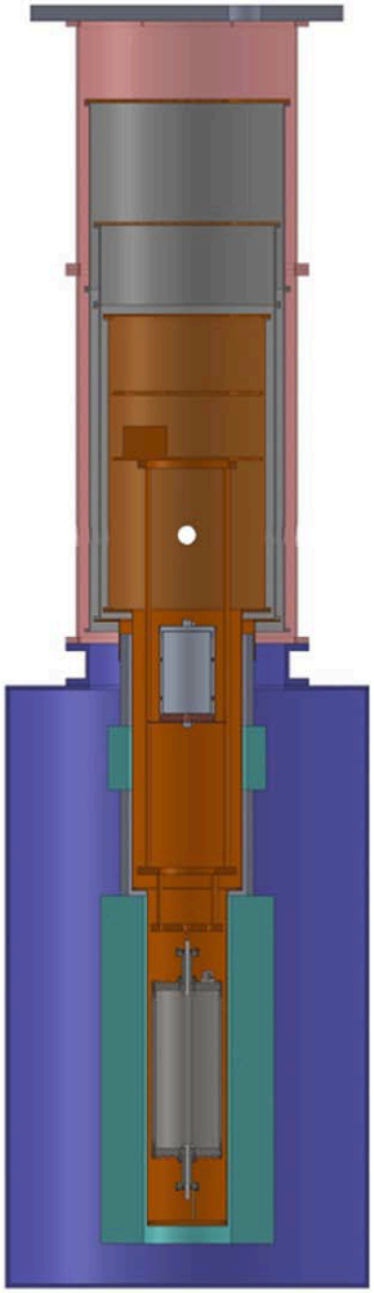
Dilution Refrigerator



Superconducting Magnet



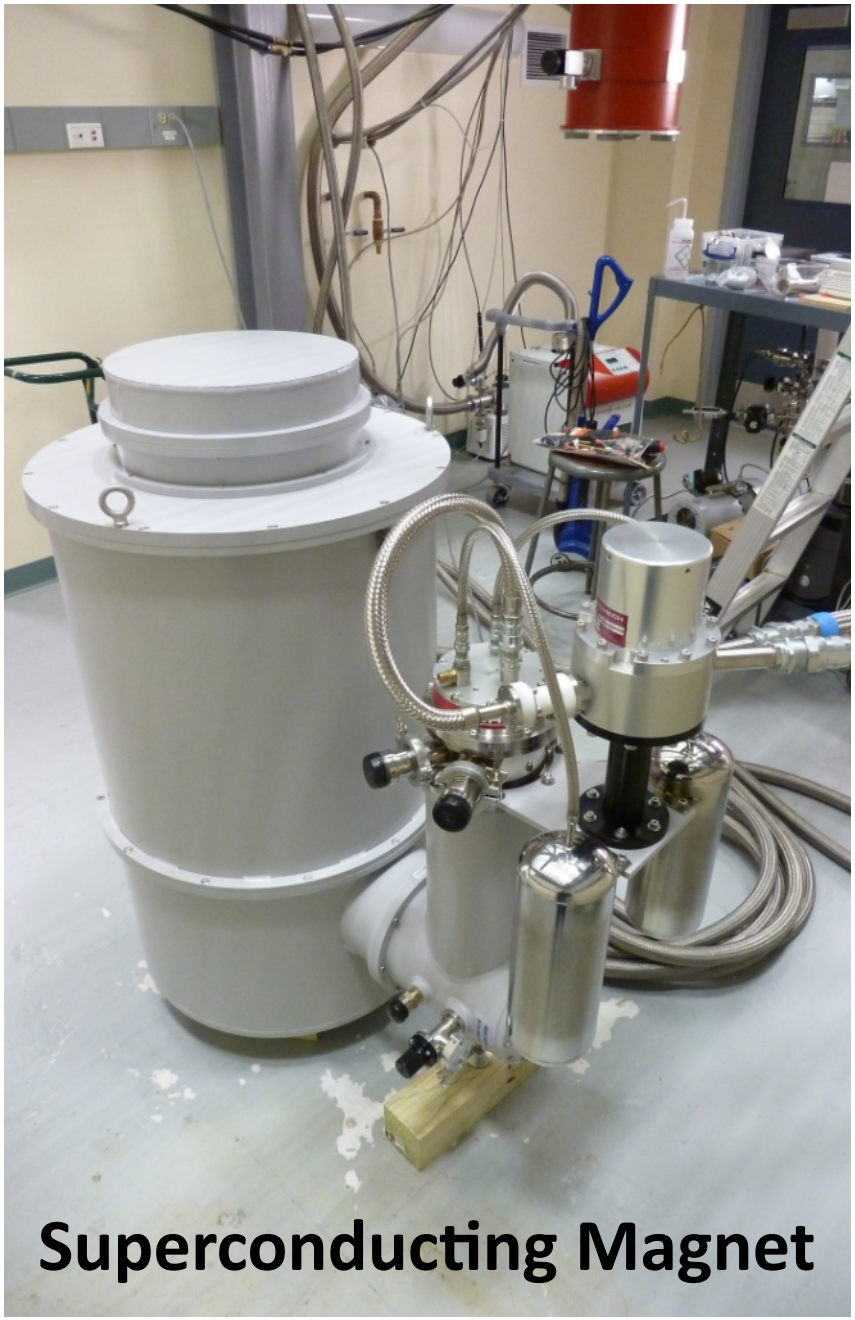
ADMX-HF
Layout



Dilution Refrigerator

- Purchased from VeriCold 2008
  - Base temperature < 25mK
- Works well, but beginning to show age
- Will procure new Blue Fors fridge (Finland) in about a year

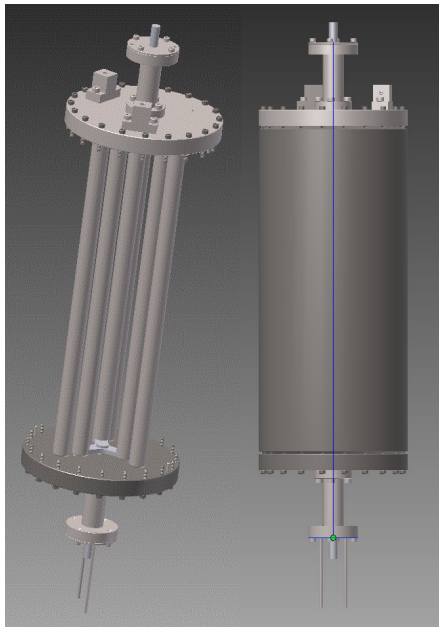
Dilution refrigerator above & below deck

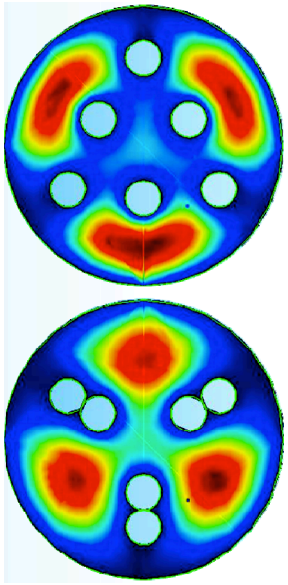


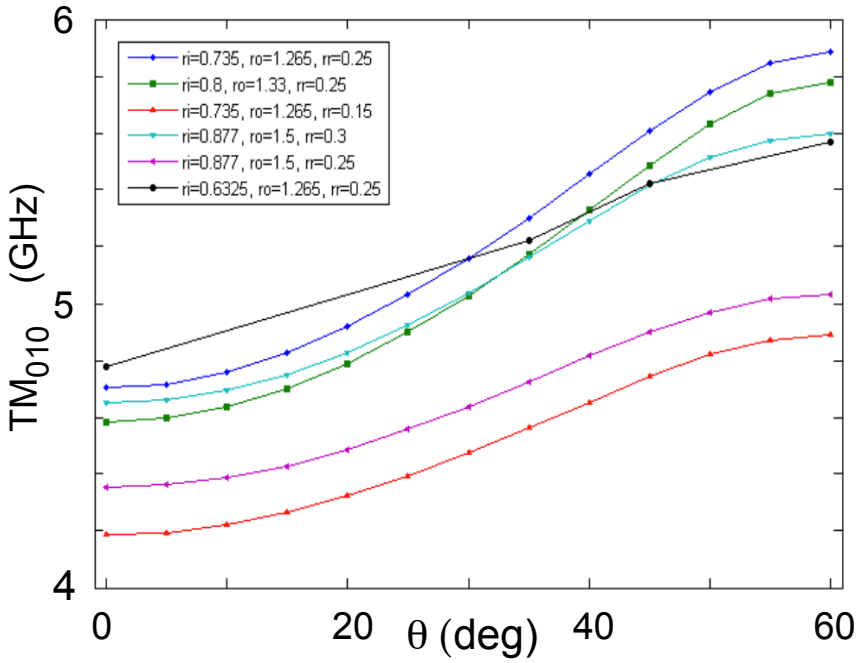
Superconducting Magnet

- Purchased from CMI
- Totally cryogen-free
- Both cost & schedule came in one-third of anticipated
- 9T, 170 H coil, persistent
- Very uniform (B_r < 50 G) for hybrid superconducting cavities
- Delivered to Yale 11/12
- Field mapping ongoing now

Microwave Cavity



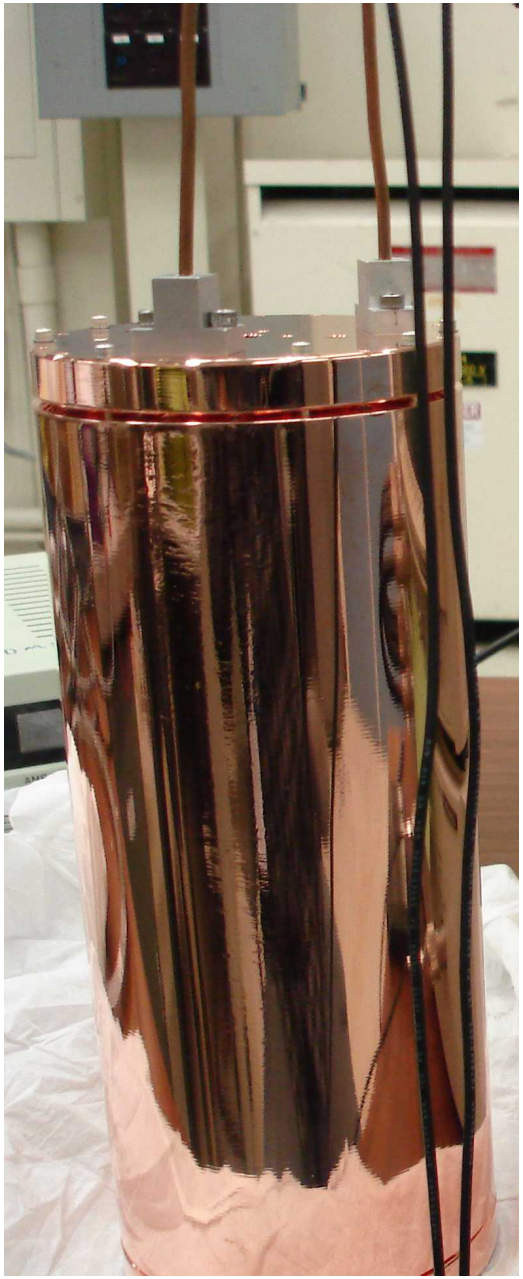


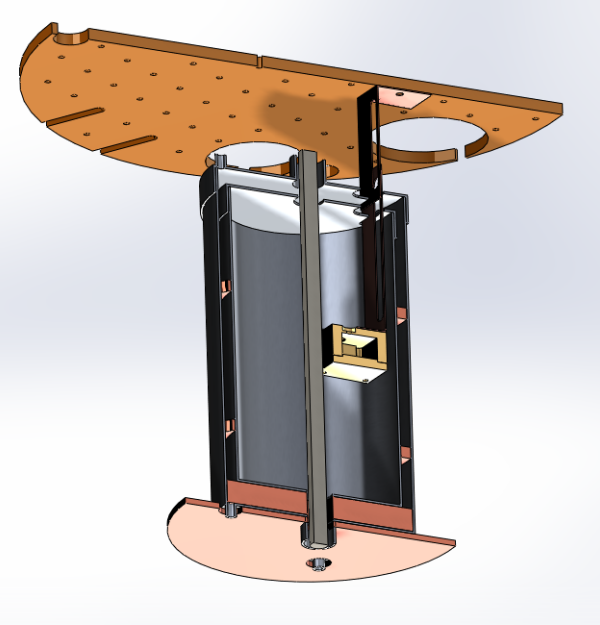


- Stator-rotor tuning design
- Cavity for first run will go from 4.6 - 5.9 GHz
- Designed UC Berkeley, modeled Yale & U. Florida, constructed LLNL

Cavity update

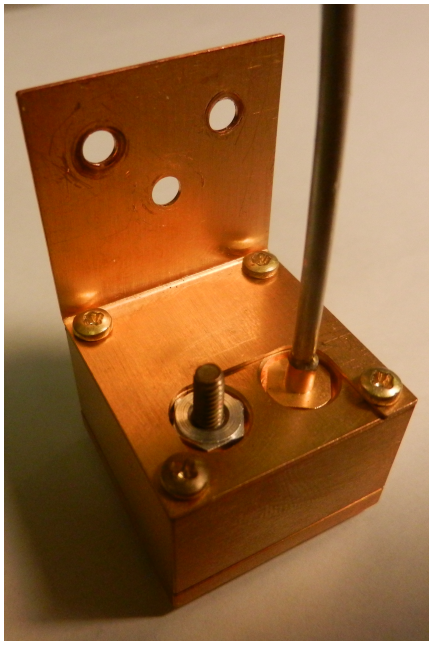
- Q = 18,800 before annealing @ 300K
- Q = 27,200 after annealing
- Should be >100,000 @ 4K (without rods)
- Looks good; to ship March-April





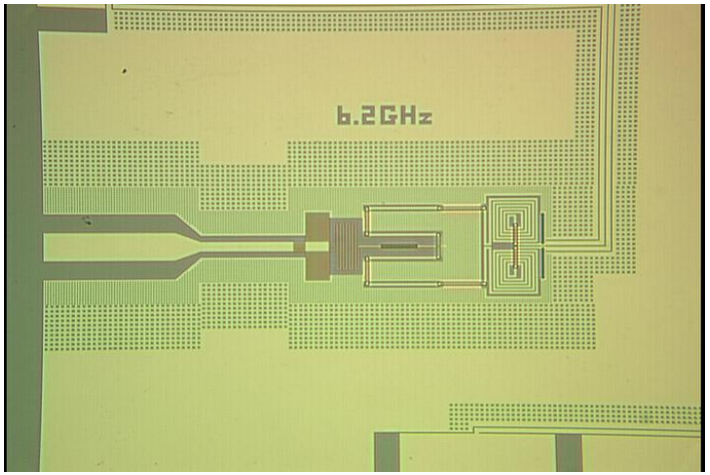
Magnetic Shielding for JPA

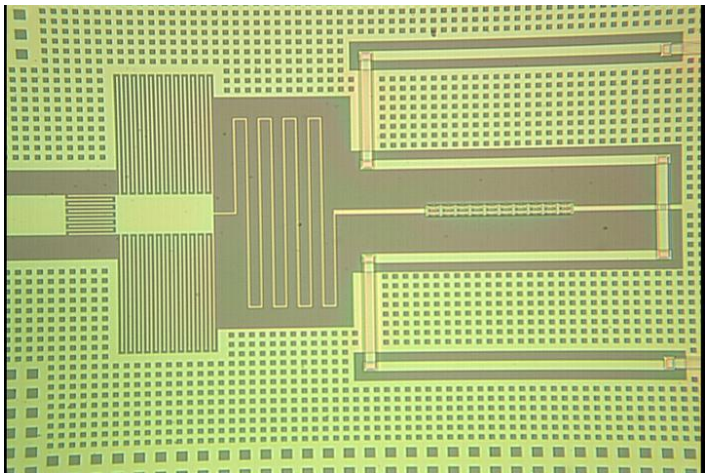
- Magnet designed with bucking coil
- Double-layer can of Cryoperm
- Superconducting housing for amplifier

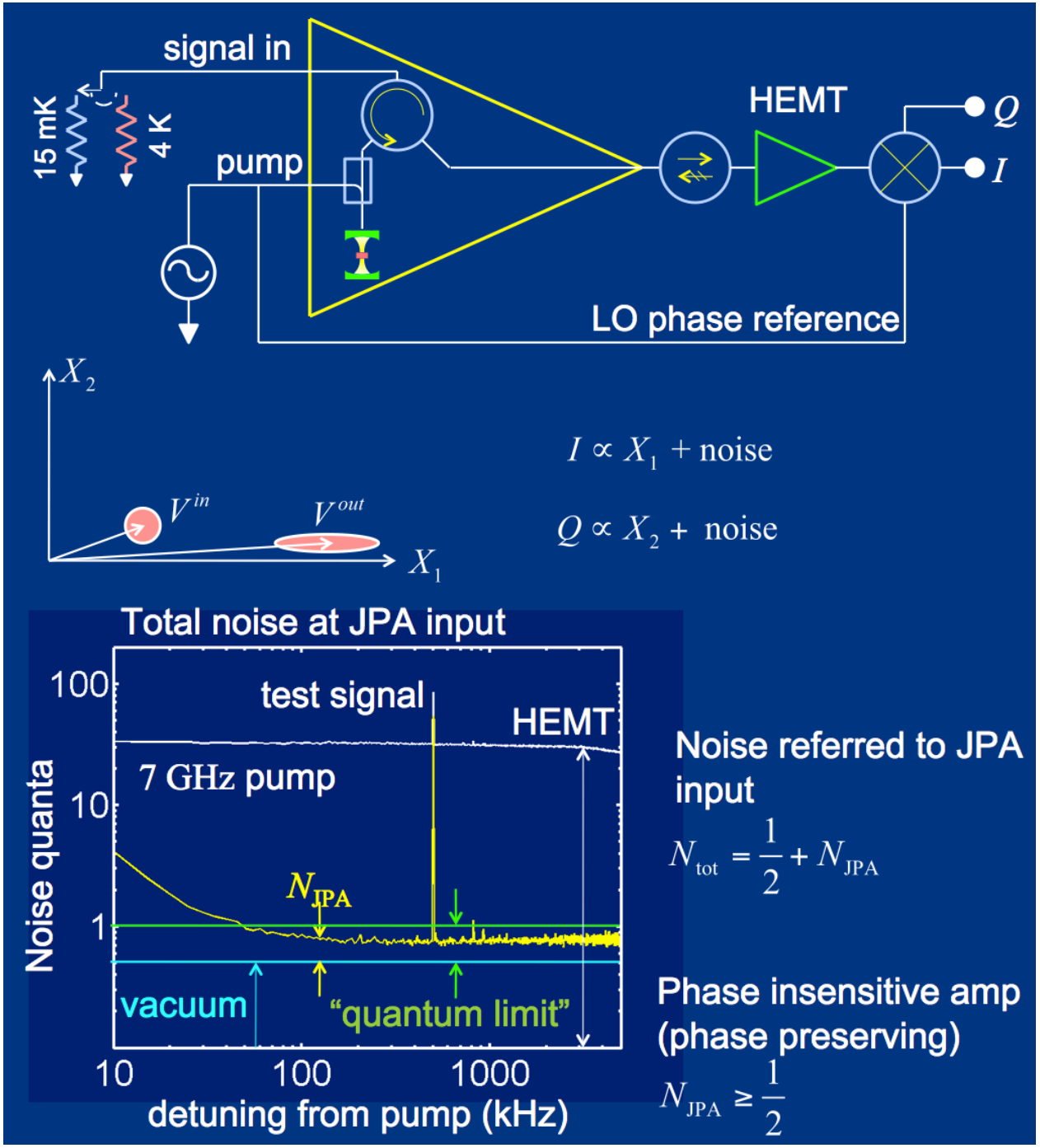


Josephson Parametric Amplifiers

- The first JPA is a copy of Konrad Lehnert's 4-8 GHz system (2007)
- Quantum-limited including HEMT
- Hand-deliver to Yale March-April
- HEMT already at Yale, shipped from Low Noise Amps in Sweden





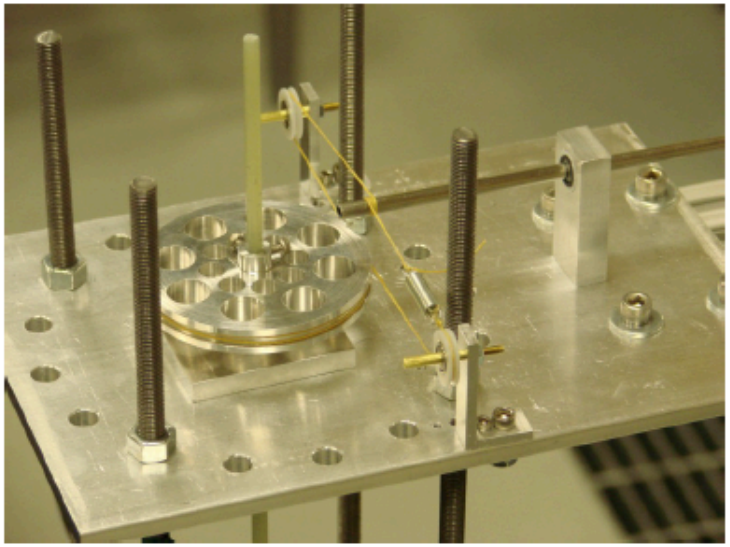


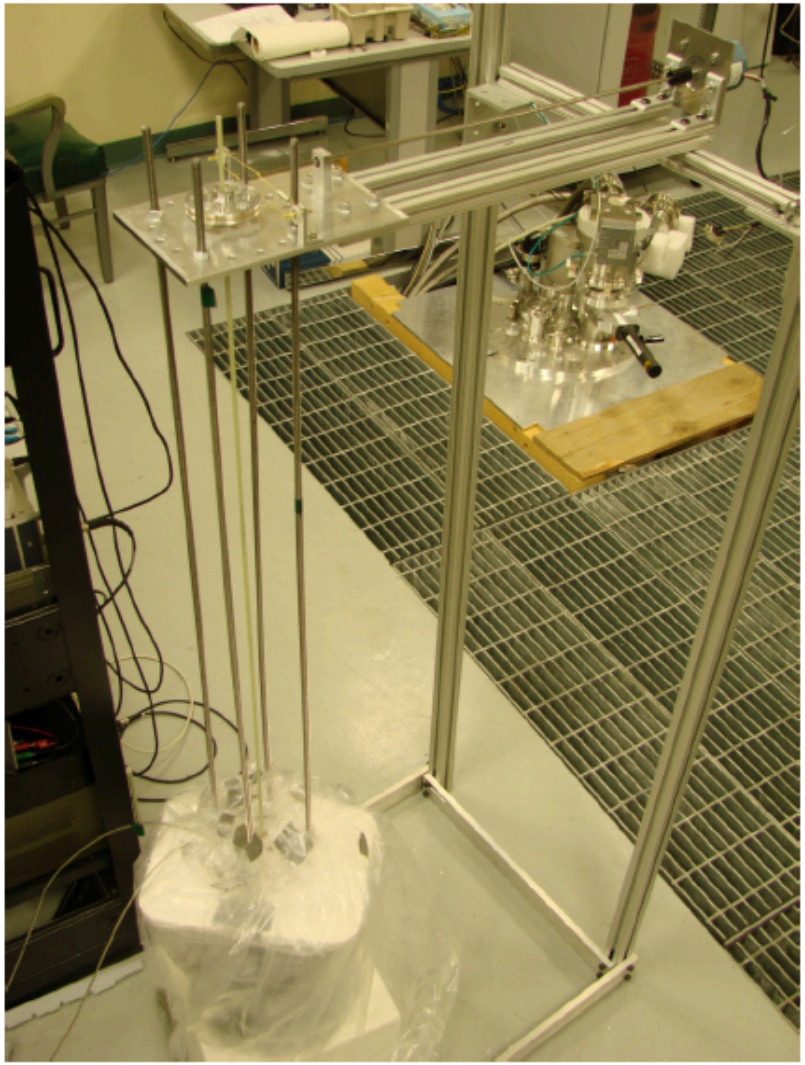
Josephson Parametric Amplifiers (JPA)

Konrad Lehnert, JILA/CU

- Natural for higher frequencies
- Broadly & easily tunable
- Operates at the SQL or below (squeezing)
- ADMX-HF will initially utilize an existing and proven system design
  - 4-8 GHz
  - Quantum-limited T

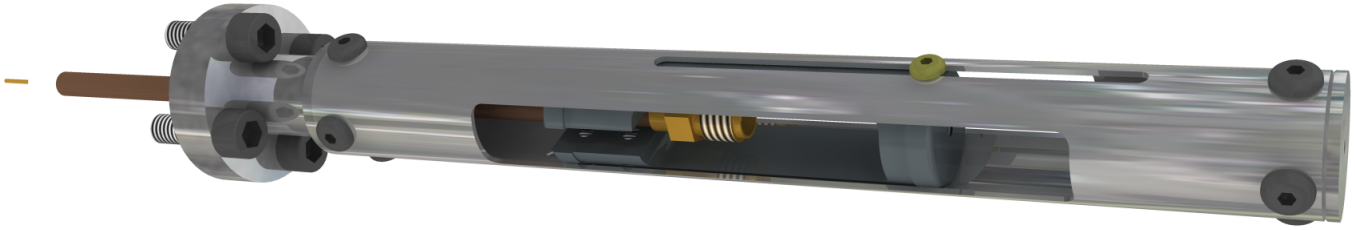
Motions designed for simplicity & robustness

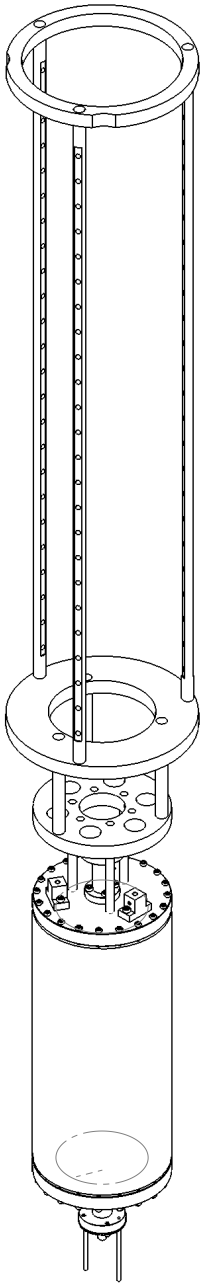




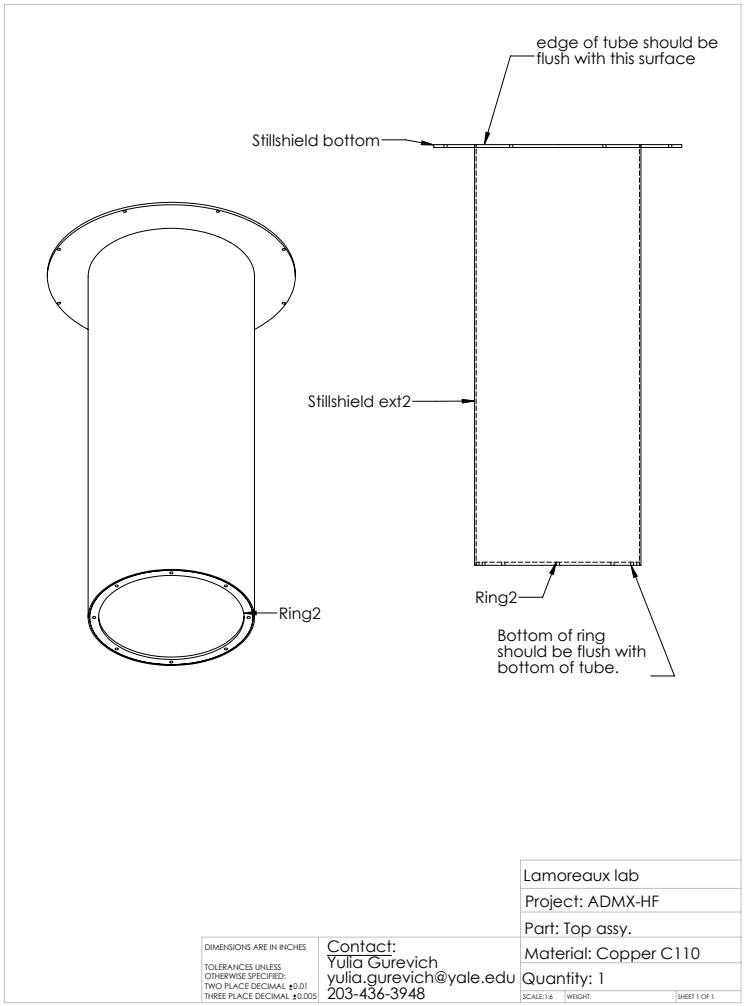
(Above & Right) String & pulley mechanism for main tuner rotational motion

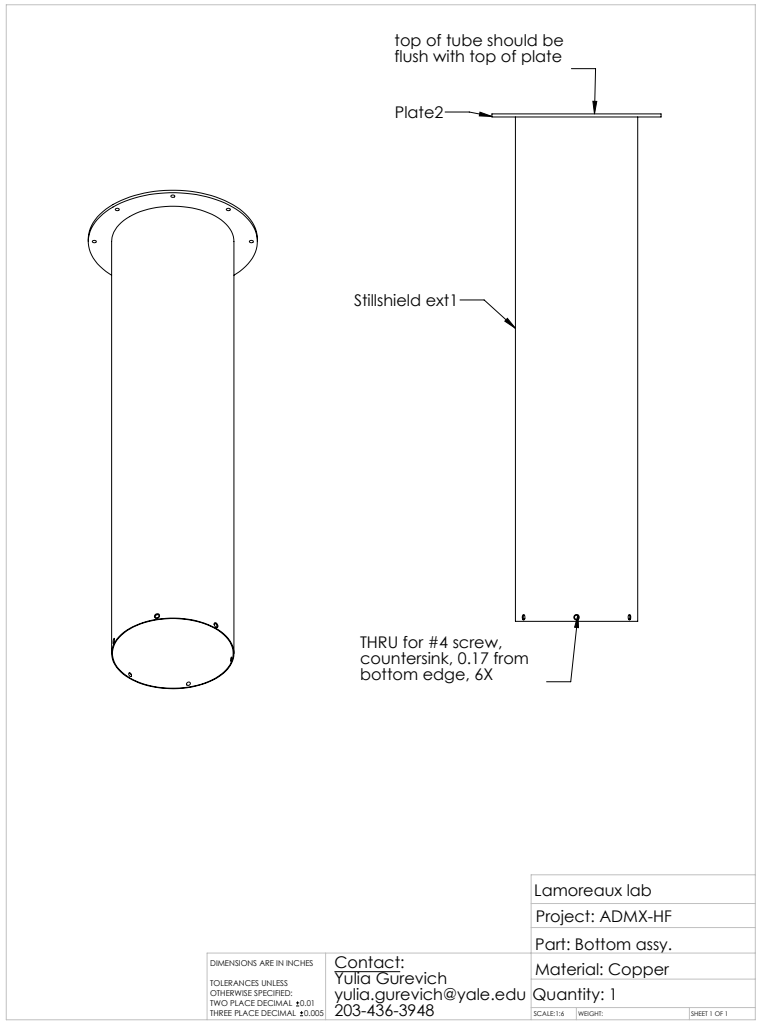
(Below) Spring-driven linear motion for tuning vernier and antenna coupling adjustment





The internal support structure is finished & being Au-plated; the thermal shields are being fabricated (C&E, Santa Rosa CA); ship 3/13

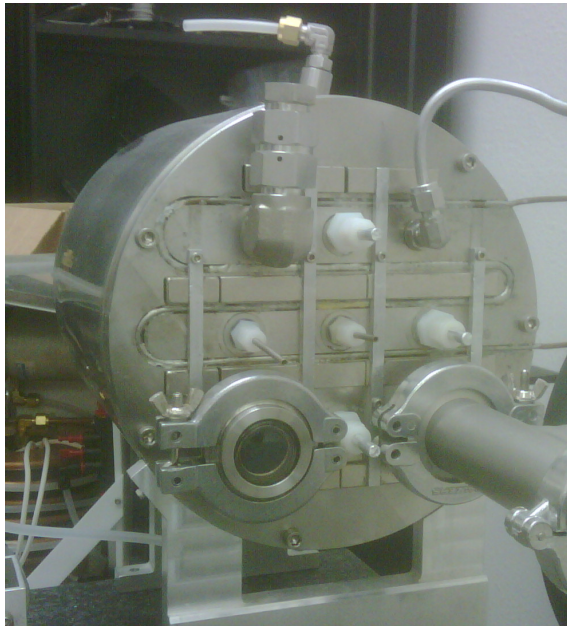




Thin film superconductor R&D infrastructure (I)

(See R&D talk of Gianpaolo Carosi)

RF plasma deposition setup (G&J Jones Co.)



UCB & LBNL tech spin-off; Similar setup at Yale

NbTiN (few 100 nm) on 4" Quartz Tube

RBS for thickness and stoichiometry

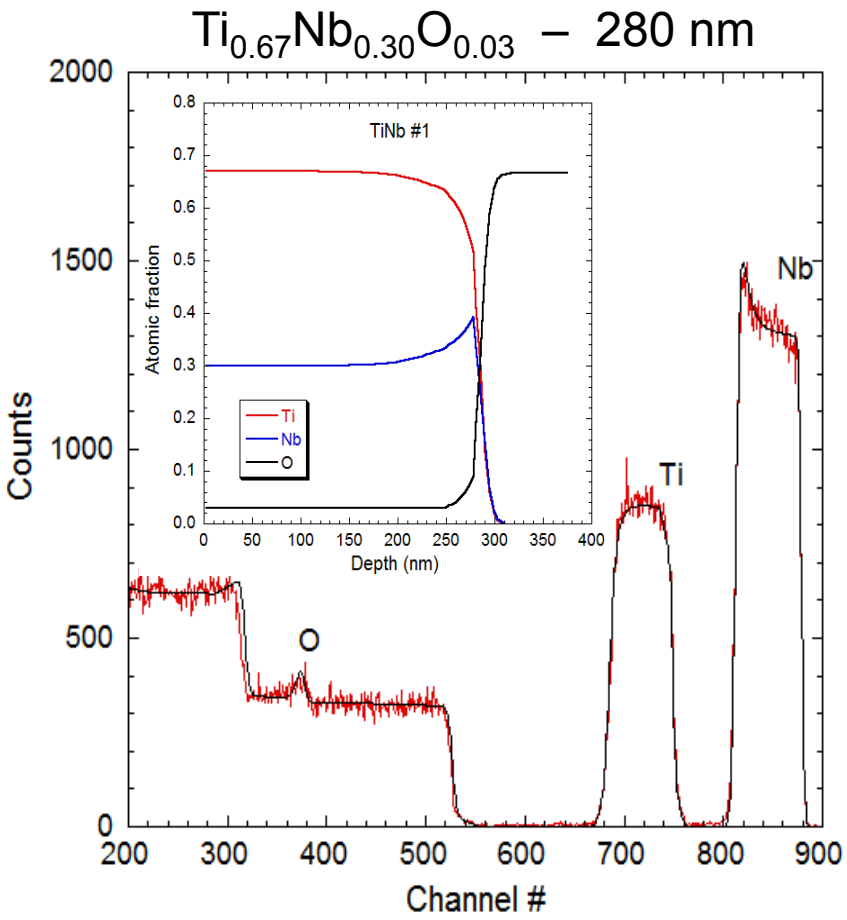
LBNL

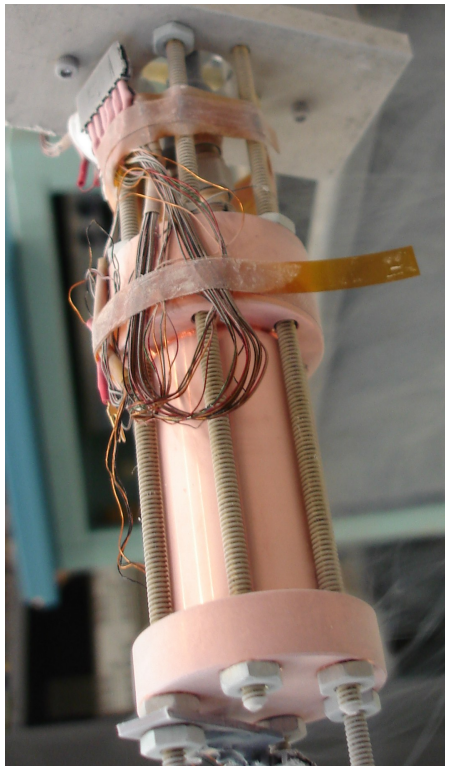
Hybrid superconducting cavity R&D infrastructure (II)

RBS depth profiling and stoichiometry

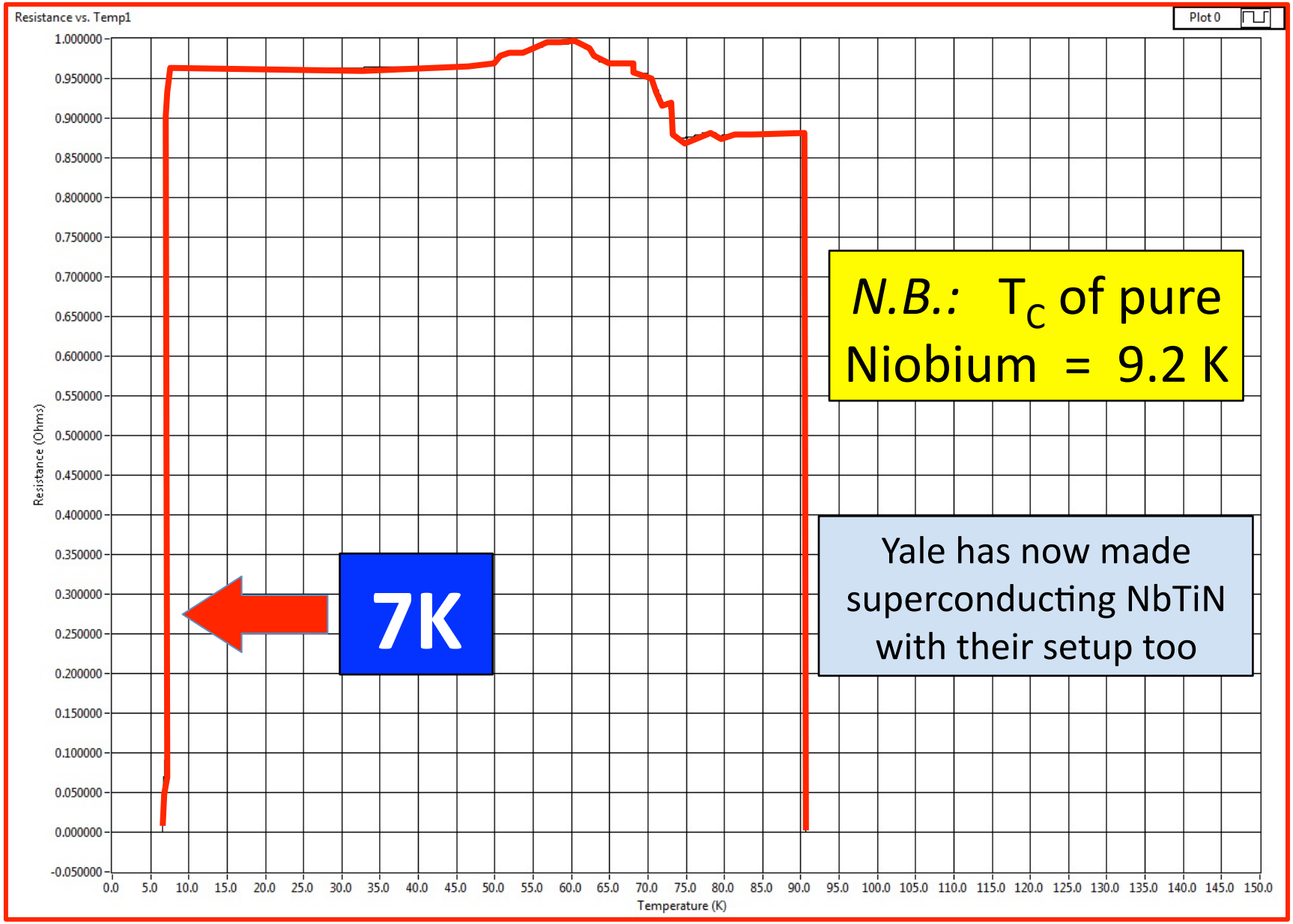
Prototype 10 GHz copper cavities

7T NMR magnet to test prototypes

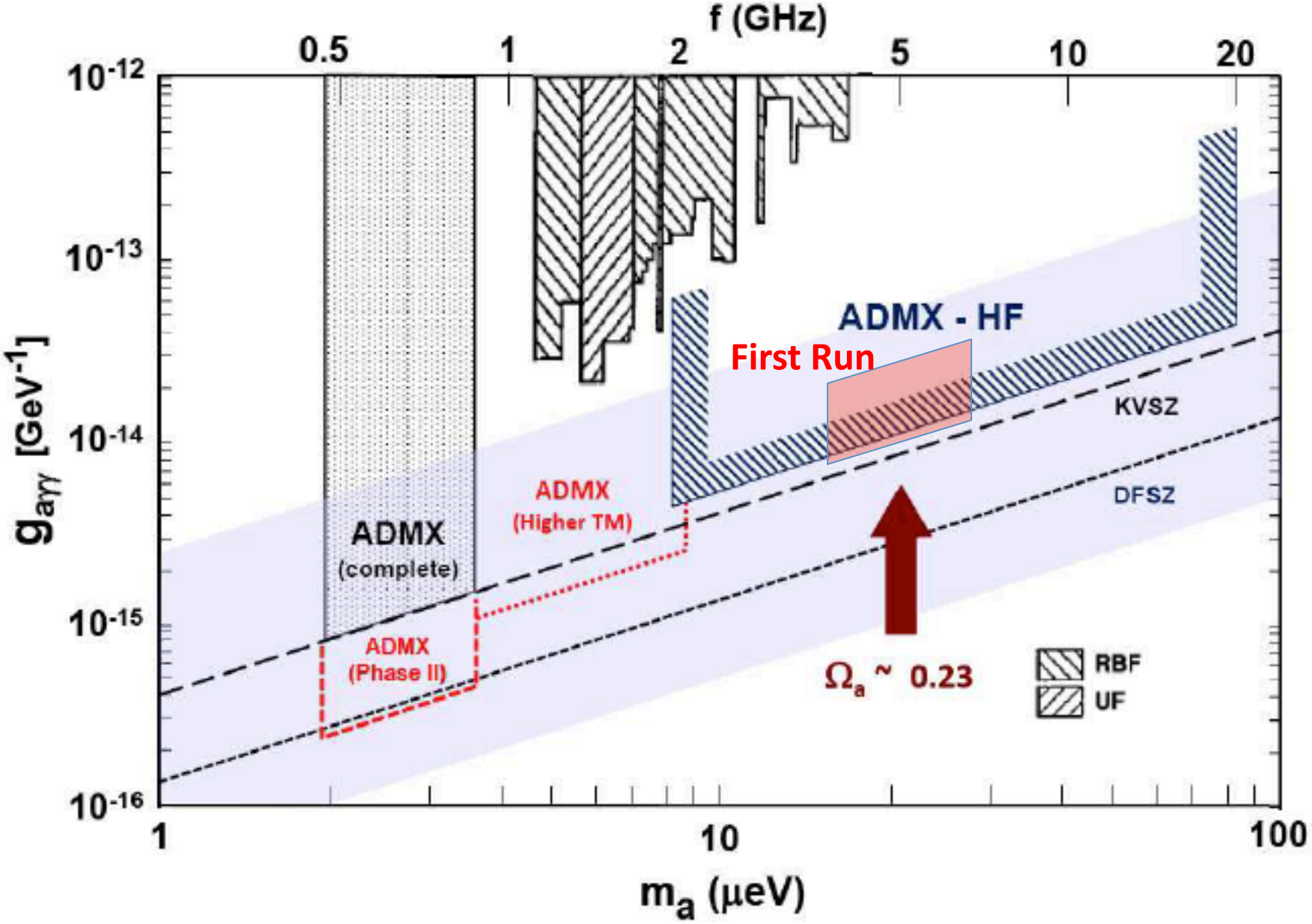




First 4-wire test of a NbTiN thin film – DC superconducting at 7K



What we hope we can achieve



Summary & projection

Everything is going very well

Mechanical integration will occur hopefully late March – early April

There's a lot of wiring & cabling that needs to take place at that point

Cold commissioning & then ramping magnet with the experiment for the first time should be this summer

First data could be soon thereafter

Many thanks to NSF!